Imagining future technologies: eTextile weaving workshops with blind and visually impaired people

Imagining Future Technologies: eTextile Weaving Workshops with Blind and Visually Impaired People

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ABSTRACT

The traditional approach for developing assistive technologies for blind and visually impaired users is to focus on problems and to try and resolve them by compensating for the loss of vision. In this research we took the approach of involving blind and visually impaired people, from a range of ages, in a hands-on making activity using an eTextile physical computing toolkit. Our aim was to create an environment where people could both make and learn form each other, but also where they would share their thoughts and imagine future scenarios for the technologies they were developing. We observed highly creative ways of working at all levels, from unique weaving techniques to choices in fabrics and materials, as well as expressions of personal preferences. We discuss the 'in-home enjoyment' scenarios sketched by the participants and point to the role of creative workshops and eTextile toolkits as a tool for imagining future technologies.

Author Keywords

eTextiles; weaving; visual impairment; dual impairment; future technologies; participatory design; accessible technology; haptic technology.

ACM Classification Keywords

H.5.2. [Information Interfaces and Presentation]: User Interfaces - Haptic I/0, Prototyping, Input devices and strategies.

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INTRODUCTION

The increasingly ubiquitous touch screen, as used in smart phones, tablets and interactive touch tables enables us with a flick of a finger to be in touch with the latest sources of information, the music we want to listen to and to see the whereabouts of our friends. However, for many blind and visually impaired users these touch screens form a hurdle as they are difficult to navigate and interact with. Various efforts have been made to ensure people with visual impairments are not cut off from the rest of society by this technological divide, by creating voice over work-arounds [22], or haptic Braille [7] input devices that can work alongside a range of mobile devices and touch-based screens. These approaches have certainly helped some users to participate in text-based interactions, listening to their emails while on the go and using texting as a form of communication. However, for blind people using these devices requires a lot of effort, is limited to being text based and hasn't quite got the feeling of fun and aesthetics that most sighted people experience when using such devices.

In our research we wanted to explore, together with blind and visually impaired users, how technologies could be developed that would be comfortable to hold, easy to work with and provide an aesthetically pleasing and fun interaction. Rather than taking an approach that focuses on problems and needs, by compensating for the lack of vision, we sought for ways that blind people could take delight in new technologies. We also wanted to create an environment where they could start to imagine how or where they might want to make such technologies a part of their life.

To explore these issues we organised creative workshops which focused around electronic textiles, or eTextiles, in which components are created by combining ordinary fabrics and materials together with a range of conductive materials, allowing technology to be directly integrated into textiles. eTextiles are fabrics, yarns and threads that are integrated with metals such as silver and steel and electronic components to create garments or other textile based objects which are conductive. Small groups of blind and visually impaired people were encouraged to create their own small samples of woven fabrics, which could then be interacted with by touching and squeezing providing a range of different sound effects. The workshops were

organised to enable people to creatively explore the use of a range of different materials and sounds, but were also framed as a place to have a shared discussion on where and how such technologies could become part of their lives. We discuss the various creative ways of working that participants developed throughout the workshops, outline the 'in-home enjoyment' scenarios sketched by the participants and point to the role of such creative workshops as a tool for imagining future technologies.

RELATED WORK

Many different technologies have been developed for blind or visually impaired users to use for everyday actions and tasks. These range from devices that support text reading that are worn on a person's finger [18] to iPhone apps that allow for users to write braille on a smooth touchscreen [19]. The focus of these technologies is to compensate for the poor levels of vision, and to replace the visual aspects of the environment through other sensory mechanisms, with many of them focusing on reading or writing. VivWiz [2] is an iPhone app which also revolves around solving visual issues but with a slightly different twist to it. The app works by blind users taking a photograph on their iPhone of something that they have a question about; this could be the colour of a piece of clothing, the precise cooking instructions on a product they have bought or whether their child has a rash. Users then send their photo and question to 'the crowd', this either being crowdsourced workers, their Facebook friends or Twitter Followers or they can email it to contacts. Brady et al explored what kinds of questions were frequently asked to try and further understand the challenges blind people face as well as to motivate research into new assistive technologies that provide independence. Whilst VizWiz clearly focuses on resolving visual problems, it also has a directly social angle by connecting people together. In some instances, for example, blind users were encouraged by the crowd to make photos from different angles to make sure the image was usable. One of the questions in the research was *'do blind people become better photographers as they use VizWiz Social?'*, pointing to issues more related to creativity than pure functionality.

Whilst these technologies hold a lot of potential for people with sensory impairments, they still revolve around a touch screen or something which ultimately feels hard and cold to the touch. There are now increasingly technologies around which are more physical and tactile, such as a vibrating belt for finding your way [13] and gloves for deafblind people that assist with translating the hand-touch alphabets, as in the work by Gollner et al. [10] and Caporusso et al. [5], also through vibrations. What is interesting about these gloves is that they are not just for the benefit of the user but also sighted people with whom they might be communicating with, opening up the possibilities for two people to communicate who might previously not have been able to speak to each other.

eTextiles are another form of technology with interesting haptic, i.e. touch-based interaction possibilities. eTextile are gaining ground in various domains, including health, in particular for their potential in sports and fitness applications or physiotherapy [23]. eTextiles have strong tactile properties and act as soft sensors - sensors that can pick up on movement through the way the fabric stretches, or touch, as people hold, squeeze or press against fabric layers to activate electronics. It is therefore likely that they can also play a bigger part in technology for blind and visually impaired people, with possibly more creative uses as well as functional.

Touching fabric is a pervasive element of human perception and many more people are familiar with the touch and feel of fibres, threads and yarns as opposed to wires and PCBs. They are also more likely to have some traditional craft skills such as knitting or sewing, as opposed to soldering or building circuits. Workshops in eTextiles are a popular method to introduce people to these materials and encourage them to use them in their own making [11]. Although a lot of these workshops are targeted towards sighted people, often focusing on how STEM subjects can be more engaging [9], there is also the potential for them to open up conversations and encourage people to be interested in technology who might not otherwise be so or who might lack confidence. Kobakant's workshops focus on more visceral outcomes, embracing the materials and their qualities [14], whilst the work by Kuznetsov et al focuses on reaching young people at risk [15]. Micha Cárdenas's work combines eTextile workshops with a range of other activities such as performance or self defence with vulnerable communities [6]. What all of these studies and projects have in common is that due to the open source nature of the hardware used, such as a the LilyPad Arduino, how it can be programmed and the different choices of materials that can be combined, participants are able to be creative and explore how it might be used in a more personal way, rather than constructing a pre-designed kit that only has one outcome.

Between its research phase and becoming a product to buy, the LilyPad Arduino itself was used in hands-on making workshops with different participants to see what creative choices they would make in using it for textile based projects [3]. Buechley et al. found that the workshops attracted a lot of girls, a very positive finding as women are statistically less likely to study computer programming or engineering based subjects. They also found that aesthetics certainly played a key part in its success [3].

For people who might be in danger of being excluded from mainstream activities, due to having an impairment or disability, hands-on making workshops can be very beneficial. Vogelpoel and Jarrold outline how these benefits include improving self confidence and mental wellbeing but that such workshops can also encourage participants to carry on with their own making in their own time, often with each other [21]. Similarly, in their research around how older people can engage with technology and creativity using the MaKey MaKey toolkit [16] Rogers et al. [17] explore how collaborating on short projects can empower people and question what more could be done to involve people in the design and uses of creative technologies. Their research highlights that people can be encouraged to

think about new design ideas for technologies by them directly engaging with such open creative toolkits in settings where they can play and explore. Such workshops can open up a creative flow, in contrast to an approach of asking people for their needs and having to come up with ideas, out of the blue - which is particularly difficult when confronted with novel ubiquitous technologies that they may not be familiar with.

AIMS

We wanted to explore whether eTextile workshops could not only be a creative hands-on experience for blind and visually impaired people but also stimulate creative ideas for future technologies. For our study we had three aims: firstly, to see how blind and visually impaired people would go about making their own eTextile objects, secondly, what creative choices they would make during this making process and thirdly, whether they would find eTextile objects engaging, and whether they could imagine them being used in their own and other people's lives.

METHODOLOGY

Our research approach was ethnographic, focusing on participatory design where we have been learning from the participants about their ideas on the wider use of eTextiles as a technology that could be very accessible to them. The workshops were designed around weaving with conductive materials, using capacitive sensing as a way for people to create various sound effects when handling a piece of fabric. The emphasis was therefore deliberately not on the programming and electronics aspects, but instead focused on the felt experience of different materials and how to interact with them.

We organised three workshops for blind and visually impaired people spread out over two months: two with an art gallery and blind people's charity as part of their outreach activities to make art accessible to wider audiences; and one with a day centre where deafblind people would come and spend the day to participate in a variety of social, music making and craft activities. The workshops had a making part to them, but there was also plenty of time to talk and discuss with the participants, and the various support workers and volunteers who helped in running the sessions.

Technology for Interaction

The wooden looms that we chose for participants to work with are small, measuring approximately 20cm in length and width, with 36 pegs on them (see Figure 1). We deliberately chose simple lateral looms that could be easily used by beginners, allowing them to focus on making and feeling their way as opposed to worrying about the tool itself as may have happened with more advanced looms using shafts, shuttles and foot pedals. Whilst weaving is a popular activity with a number of blind and visually impaired groups [4, 12] - where they use large complex looms - this is a skill that takes many years to master and in consultation with occupational therapists we settled for this

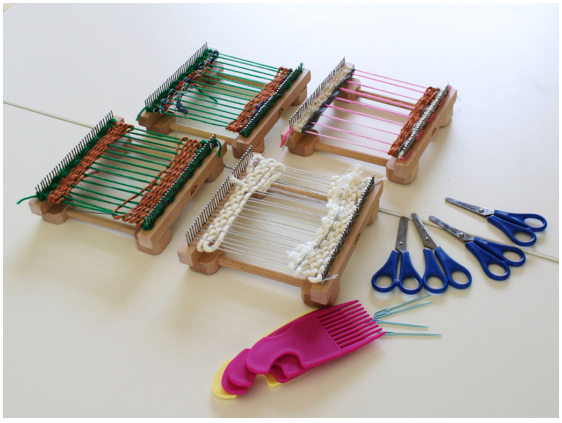

Figure 1: Looms set up on the workshop tables with the warp on them and a bit of the weft as a starting point.

particular shape loom as one in which all aspects of the loom could be readily felt and understood.

We set up the looms with the warp already on them (this is the yarn which goes around the pegs that the participants had to weave through), using both non-conductive and conductive yarn to ensure that their work would end up

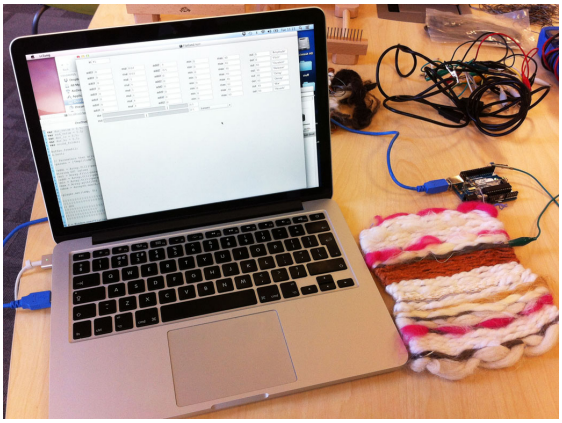

Figure 2: The technology set-up: a laptop running the SuperCollider application, an Arduino board with capacitive sensing and eTextile woven swatch connected by crocodile clip.

being interactive even if a participant did not choose much conductive material to use in their weft (the part that is woven through the warp to make a finished piece).

The interaction with a finished woven piece, i.e. a swatch, was accomplished through capacitive sensing. For this we had uploaded a capacitive sensing sketch onto an Arduino Uno board [1] which communicates with a patch in SuperCollider [20] (see Figure 2). The circuit is very simple, with the woven swatch (connected through a crocodile clip) acting as a sensor that the Arduino takes readings from as it is touched. These readings differ depending on the type of touch, whether it be squeezing, stroking or rubbing and is also dependent on the type of materials used with some being more conductive than others. SuperCollider takes in the sensor readings from the

Arduino board and from them changes the sound output in line with the changing values, which makes the music responsive and interactive. The sound files ranged from wind chimes to crunching leaves; and we were able to change the sound file even as the interaction was happening, to find out which sound was of most interest to a participant, and adjust the responsiveness of particular music files by changing some numbers in the file.

We chose to use Arduino and SuperCollider, as opposed to using the inbuilt sound circuit on the Arduino board itself which has a more crude sound output, in order to be able to pick up on the smallest changes in readings associated with very light touching, and with fine differentiations in the type of materials used.

Materials

For the actual weaving activity, we chose a variety of different materials, conductive and non-conductive, for the participants to use, all of which varied in their texture, colour, thickness and sometimes in smell too (see Figure 3). The intention was that by including such a variety of different yarns and fabrics that participants could express some of their individual preferences, and make choices. This was not only to observe if these different materials evoked different reactions, emotionally, but also how this impacted on how they were handled.

Figure 3: The different materials participants could use in the workshops.

The Participants

The three groups attending were quite varied and we did not know until the day of the workshops who exactly would be there, nor how many participants to expect, as our partner organisations were responsible for the recruitment and sign-up process. The first group contained three older people (50+), two of whom had been sighted all their lives but became visually impaired as they aged. The third participant went completely blind in his thirties. Their workshop took place after an audio descriptive tour at the gallery space, so the creative weaving workshop was linked to the artist's work on show.

Material	Qualities
Conductive	
Stainless steel fibre	Resistance of 740 nΩ.m, smells metallic, has heaviness to it, difficult to tear, good for felting, grey.
Stainless steel and polyester yarn	80% polyester 20% stainless steel, Soft to touch, not very elasticy, surface resistance: < 104 Ω, good to make sensors with, light grey.
Stainless steel thread	Resistance of 1.4 Ohms per linear foot, smells metallic, thick, has heaviness to it, tricky to sew circuit with, grey.
Silver plated thread	Resistance of 40 Ohms per metre, soft to touch, good to sew circuits with, very thin, grey.
Tin copper tap	Knitted metal tape, resistance of 14 ohm/meter, grey.
Conductive fabric - 3 layered tin, nickel and silver over nylon - Ripstop	Resistance of < 1 ohm/sq, very papery to touch, light grey, frays when cut.
Conductive fabric - silver plated nylon	Resistance of < 1 ohm/sq, 180 Ag Nylon single directional stretch, 78% nylon & 22% elastormer, dark grey.
Non-Conductive	
Jute fibre	Straw like to touch, slightly rough, sandy coloured.
Milk protein tops fibre	Extremely soft, easy to tear apart, white in colour.
Merino wool tops fibre	Soft, easy to tear apart, different bright colours.
Cotton yarn	Soft, cream coloured.
Linen yarn	Rough, rope-like, thick, 2/1.3 nel., copper coloured.
Unwashed wool fibre	Smelly, greasy, hard to tear, very matted bits, dirt in it, brown in colour.
Acrylic yarn	Soft to touch, almost elasticy, different colours.

Table 1: Materials used in the workshops and their qualities.

The second group consisted of 12 young people, with different visual impairments and learning disabilities, some of them being completely blind as well as autistic. This workshop was also at the gallery space and so like the first

workshop took place after an audio description tour. They attended through a community youth programme which has monthly outings - on this occasion to the gallery.

Every participant in the third group had learning disabilities, some severe, as well as being blind, visually impaired or deafblind. They needed a significant amount of help with their weaving with some of them also having no speech.

For groups 1 and 3 we had access to specific participant information (see Table 2), but for group 2 we did not. Participant's names were changed for confidentiality.

Age	Participant	Impairments/ Disabilities
GROUP 1		
50 - 60	John	Completely blind, is comfortable with making things and is an artist.
65 - 80	Shelley	Visually impaired, knows a lot about materials and crafts, was a teacher.
65 - 80	Liv	Visually impaired and chairs quarterly meetings for blind and visually impaired people.
GROUP 2		
15 - 25	Jennifer Dave Jim Zo Nazmeen Will Andy Tariq Moh Sabine Tamina Zina	Most participants were visually impaired, with three being completely blind, three being autistic and one with learning disabilities.
GROUP 3		
29	Heather	Completely blind and uses her right ear as a preferred side to hear out of. Has a learning disability, enjoys talking and is interested in singing.
25 - 29	Nicolette	Has bi-lateral hearing impairment, a visual impairment, left arm is absent from below the elbow. Has not much speech and has mobility issues but can walk. Has learning disabilities.
20 - 29	Tanya	Blind (sees bright light), has good hearing, wheelchair user, learning disabilities, cerebral palsy, no speech. Enjoys making continual vibrational sounds with fingers and lips.
20 - 29	Anna	Almost completely blind but with tunnel vision in her right eye, profoundly deaf, cerebral palsy. Enjoys craft activities and has good manual dexterity.

Table 2: Profile of participants who took part in our workshops.

The Workshops

Each workshop differed very slightly in our approaches due to the variety of participants. The workshops also varied in time from two to five hours, depending on whether they had to fit in with other activities, such as touch based audio tour of the art gallery (workshop one and two) or a long extended lunch break as part of a fun day out.

We began each workshop by briefly discussing eTextiles followed by passing around an example eTextile woven swatch for everyone to explore with their hands and demonstrating how it can be interactive. This immediately allowed for the participants to understand how this was an object that can create interaction as opposed to just being normal textiles. This was then followed by participants working on their own swatch using the materials that they chose. We developed a style where all materials that could be used for weaving were put together on a separate table, and we encouraged participants to walk up, feel the various textures and fibres and select the ones they wanted to use so as to make them feel in control of that part of the process.

In each workshop the participants were guided by a variety of support workers and volunteers who showed them the process by guiding their hands (see Figure 4). Once this was demonstrated to them, participants carried on with their work independently, occasionally being helped to find the scissors or to be guided to the table with materials to make further choices; while in the case of people with severe learning disabilities, assistance was on hand continually and adapted to the individual needs of the participant.

Once participants had finished their work we helped them lift their weave off the loom and connect it to the Arduino board to interact with the audio in SuperCollider. We either carried the laptop around and brought it to the participants or participants walked over to us to take their work off the loom and interact with it. People were given a choice of audio to experiment with, being playfully encouraged to look for the sound they liked best or that provided the best effect for them.

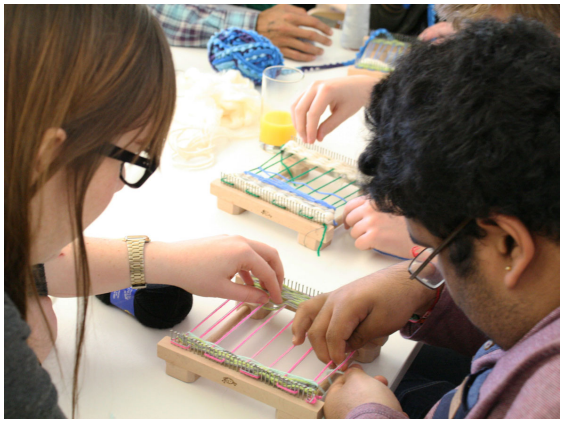

Figure 4: Participant weaving.

During the first and third workshop we had discussions with participants about the possible uses of eTextiles during the activity itself but with the second workshop we did this at the end, as a brainstorm discussion with the whole group. The first workshop was more informal and so these discussions happened naturally; due to many of the participants in the third session having little to no speech, it was more about observing their interest in the activity and their response to it.

DATA ANALYSIS

Following a participatory research approach we were immersed in the workshops as people who would provide hands-on support and guidance to participants and the volunteers. All workshops were documented through informal notes from various observations jotted down by the researchers, transcriptions of recorded conversations and discussions where these were audible, and study of photos and video materials of the sessions. Through sharing these various notes and in-depth discussion within the team a number of themes were identified under which we report our findings.

FINDINGS

Whilst there were a lot of differences between the participants, in terms of their age, their background, their health issues, cognitive abilities as well as their level of visual impairment - it was surprising how all experienced creative and exciting moments from doing the activity. People worked in a concentrated, focused way - taking pride in their work and keen to complete their sample in order to experience the sound interaction. There was a relaxed atmosphere in the group, with people showing their progress to each other and sharing associations about what they were doing and aspects of their personal their life.

From Apprehension to Confidence and Enjoyment

Initially participants expressed a sense of apprehension about the task they were embarking on, but this apprehension gradually disappeared as they started to work on their piece. John, during the first workshop, explained that as a blind person he felt quite anxious being asked to do weaving - as he felt that this was clearly not something he could be expected to succeed in doing without being able to see. However, as he started to work on his piece and realised he could feel with his fingers where the warp and weft were, and that there was no right or wrong way of weaving the thread, he relaxed into a focused style of work clearly enjoying the regularity of the patterns he was creating. Liv, also from workshop one, initially treated the idea of eTextile technologies with great suspicion, reflecting on all its possible evil purposes *'...you could put in people's number, you can give them a number 649786, and press a button, and then they die...*". Her thoughts were echoed by Shelley "*This is all a bit scary. This is all a brave new world that we're into now*". It is possible that their suspicions were caused by a similar anxiety as mentioned by John about the task itself as Liv was initially keeping her loom close up to her eye, using a strong lens, in order to use the glimmer of sight she still had, to see the weaving pattern. Once she realised she'd be able to feel the weaving pattern with her fingers she also relaxed into the work, explaining how this reminded her of the tapestry work she used to do and that she hadn't been able to do for some years now.

In one of the other groups, Jennifer who has autism, was seen anxiously flinging her arms around, pushing all the materials far away from herself as if scared to touch them. A volunteer explained that Jennifer was fearful of the prospect of '*…connecting things to a computer...*' but we noted that once she got over her initial hurdle through the patience of the volunteer working with her, she was seen cooperatively pulling wool as well as milk protein tops, her favourite material, through the warp on the loom. She never went as far as wanting to hear her piece through the computer software, but was happy for others to demonstrate their pieces to her and indeed, for others to demonstrate the sound of the piece she had worked on to her. We understood from the carers who knew her well and were better able to interpret some of her behaviour, that she was clearly enjoying herself and would go home talking excitedly about the event she'd been to that day.

It appears therefore that some of people's initial anxieties were related to their not being able to see what they were doing and that this was an unfamiliar task. However in each workshop we saw examples of people rising to the task and what they were making.

Responding Creatively

There were many examples of people working creatively, giving their own meaning and personal touch to the piece they were making. The materials themselves provided much opportunity for people to express themselves, with participants having clear favourites among the range of materials available. One very peculiar type of fibre, milk protein, has a very smooth, super soft feel to it, and Nazmeen, from workshop two loved using it, saying *"It feels like marshmallows"*. In workshop three, Nicolette, who has a little bit of vision but is unable to speak, had carefully selected a blue bobbly yarn to work with, brought it to the table, and was seen enthusiastically banging the bobbin on the table to emphasise that this was the yarn she

wanted to work with. Tanya also enjoyed plucking at this blue bobbly yarn, and went on to tasting it in her mouth, rocking herself forwards and backwards, being clearly excited about the unusual feel of this material.

There were mixed reactions to the smelly unwashed sheep wool. In workshop one Liv excitedly exclaimed "*My God he's a smelly old animal that this came from!…My God he's a smelly beast!"* while several participants in the third workshop kept holding it up to their noses in order to smell it and holding it out to others for them to smell. For Heather, also from workshop three, the sheep wool brought up happy associations with her favourite story about Peter Rabbit (a story set in the countryside) and she was clearly excited about this connection between the wool and her story. In workshop two, interestingly, none of the participants wanted to use the sheep wool as it was seen as filthy and smelly.

We observed how many participants developed their own techniques with regards to weaving. Using the loom provided enough constraint for people to have a framework in which to work, making it a task with clear boundaries, but it also allowed for many different creative approaches to complete it. Jim and Nazmeen, from the second workshop, developed a technique where they would go back on themselves with each weave before going forwards again, wrapping the yarn or fibre around the last one (see Figure 5). This is an unusual weaving style, not dissimilar to a hand-manipulated style known as 'Brooks Bouquet' [8] but clearly the participants were not aware of this style and had made this up themselves. Sabine, also in the second workshop, and who is completely blind, clearly had been struggling with the issue of threads escaping from the warp when it was being pulled through, and so she and her support worker developed a style of knotting a thread to the warp before starting to weave it. They were sharing their insight with others around them at their table and Sabine was pleased to show others how well this worked *"Look, I am racing through this!"*, showing how her needle was swiftly going up and down through the warp.

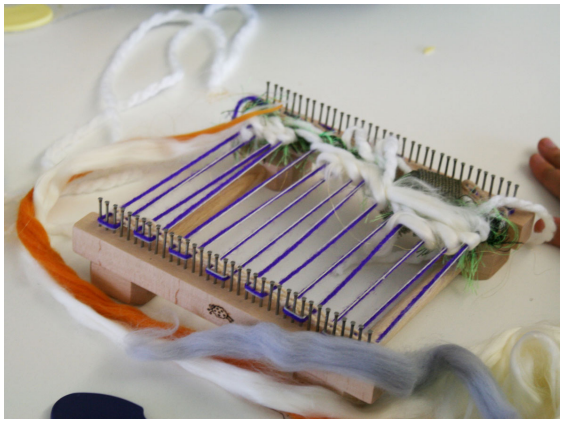

Figure 5: Nazmeen's 'Brooks Bouquet' weaving.

Once people had finished weaving their swatch, it would be taken off the loom in order to connect it to the laptop, through a crocodile clip and Arduino board. The moment of taking the swatch off the loom in each case caused some consternation - as people were eager to feel their piece, but they were also worried it might fall apart at this point. As Sabine felt her piece just as it came off the loom she exclaimed, with clear delight, 'O*h, this feels so creative!*'.

Not only had people developed their own technique, but by each person choosing their own yarn, as well as choosing in which order to use the different yarns and fibres, how long to use each yarn for, what type of weave pattern to follow (if following one at all) the overall effect was one of huge variety (see Figure 6). Each piece was quite distinct from the others and people were seen stroking their own piece, as well as that of others to get a sense of what each person had made, with people being delighted by their own effort and

Figure 6: Different eTextile swatches created by workshop participants.

feeling how it differed from other people's.

Interacting with the Electronic Textiles

While weaving with a variety of the materials, participants had to be reminded to make sure they would include conductive materials as well as ordinary fibres in order to make sure the piece would end up as an interactive piece. This aspect was of particular interest to the participants in the first group who, after their initial apprehension, were keen to really understand the conductive properties of some of the fibres. Liv spent some time exploring the silver plated nylon conductive fabric, which was a tricot fabric, only stretchy in one way, and Shelley who was very surprised about the properties of silver plated conductive thread, saying:

"This is an electronic kind of wire? Oh I see, so this is really plastic in its way. It feels silky, but it's plastic. It's a viscose of some sort and, if this is electronic, what are you sewing into your clothes then?"

When Liv's piece was finished and connected to the Arduino board's capacitive sensing circuit, she squeezed and felt her woven piece describing one of the sounds it produced as being like 'glass' or 'raindrops' and thought it

was as if the textiles were 'speaking'. Another sound (the 'MusicBox' sound) made her very excited *"Ah, this is a very nice thing, it's beautiful"*. While gently swaying her fingers across her piece, she also wondered if different materials and colours might trigger a different volume of sound:

"I want to see what the blue sounds like…now what does the sheep's wool…and this is the jute. So it has changed because this is the one which is electrified or whatever you call it, and this one is conductive. That's interesting as it's not as loud, this is much louder. This to that, it's musical. So you could compose with this! It could almost tell you if it's dark or light in colour 'cos it goes up and down…"

The technology clearly sparked her imagination and she was able to draw various creative links between the felt experience of the fibres, their colours (some of which she was able to see and others she imagined were there) and their interactive behaviours. It was particularly remarkable to see her work the piece with such curiosity and delight, having put aside her initial reservations, and being able to speculate about what such textile pieces would be able to do. She also speculated how these effects could be even further enhanced through other felt effects, such as vibration, which she had come across as a participant in other research projects.

With all participants the moment of taking the woven piece from the loom and connecting it to the Arduino board for interacting with it - was a special moment, and something they much enjoyed. Participants were quite different in the way they would handle their piece - some hesitantly touching it, with careful fingers feeling it - while others had a more robust style of squeezing and folding it. We made sure that participants could feel how the computer was connected to the Arduino board and the crocodile clip to their piece - by running their hands across the cables - and most seemed satisfied with that explanation. However Sabine, from the second workshop, who is completely blind and autistic, clearly wanted to understand the entire set-up in some detail. She kept feeling not just her woven piece, but also the Arduino board, and the cabling to the laptop, its keyboards and mouse. Although she was familiar with laptops, the various hardware components involved in this experiment clearly intrigued her, not having come across Arduino boards and various other electronics previously. Another participant in workshop one, Tariq, developed a particular style of sounding his woven piece, by pulling at the crocodile clip and its cable. He played it as a base guitar, pulling at the strings, rather than handling the woven piece itself. He enjoyed the effect as even with this unusual style of touching the piece, it still provided a good range of sounds.

For some of the very disabled participants in the third workshop it was the sounding of their piece that made them particularly pleased. Some of them, including Tanya and Heather had not been able to do much of their own weaving, and for them hearing the sounds was when the activity became alive. Tanya wiggled her entire body as an indication that one sound was more her favourite than the other, while holding the piece in her hand and mouth. While Heather was delighted with a particular sound, the 'Jew's Harp' sound, which is very bouncy and reminded her of a rabbit, bringing up again her favourite story character Peter Rabbit and causing her to react quite physically to the

Figure 7: Heather interacting with her eTextile swatch.

sound, clearly excited by it (see Figure 7). She said she would call her woven piece 'Rabbit'.

We thus noticed that people were engaged with different aspects of the technology. Some people particularly focused on how different conductive materials had potential for different interactive effects, including projecting connections between colours and sound, whilst others were intrigued by the hardware components of the set-up, and wanting to understand how it all fitted together - and for others sound was something that spoke to them, giving a chance to associate between their textile piece and sounds that they enjoyed. For one of the very deaf participants, Anna, the sound effect was inaccessible, but she was made aware of the changing lights in the SuperCollider application and while she also had limited vision, we believe she was able to make a connection between her gestures and the flickering lights, which she studied with intense concentration.

Imagining Future Technologies

As people had relaxed into their weaving, creating interesting sounds and helping each other with various techniques, the workshop setting was clearly a fruitful environment to generate a range of imagined further uses of eTextile based technologies. An initial suggestion by one person had been that eTextiles might be useful to create garments to detect the onset of a stroke - whilst later these participants moved away from such serious applications towards more playful examples that they could imagine having in their home. The musings about associations between colours, fibres and different sounds left one participant thinking about larger displays in her home, that would give off various playful sounds when you walked up to them and felt them. She also reflected how she would enjoy making those sorts of displays herself. Several ideas for new musical instruments were voiced - either to

compose pieces using eTextile displays, or as suggested by another participant not so much using textile elements but using the underlying notion of capacitive sensing with other metal based materials. Participants also talked about carpets with conductive properties that would make sounds, perhaps to play tricks on visitors, or other jokes, while for one younger girl it was more something she imagined being surrounded by, perhaps as she would fall asleep in bed.

Several of the care workers articulated that this type of technology also comes close to how they work with sensory rooms, where people with sensory impairments get a chance to explore a rich variety of sounds, lights and other felt experiences. This sentiment was echoed by the girl who had likened her woven patch to Peter Rabbit, as she wanted her piece to be part of story telling - an activity she much enjoys.

All the examples that were brought forward were positive, creative ideas, that would liven up one's sitting room or surprise visitors in a fun and lighthearted way. From not knowing anything about eTextiles at the start of the session, and never having worked with Arduino or other toolkits, the success of their accomplishments had given participants the confidence to propose new design ideas. Many of the design ideas were not particularly practical, or functional, but were more inspired by aesthetics and about creating playful encounters as part of their daily environment.

DISCUSSION

The creative workshops with blind and visual impaired participants were enjoyed by all, forming a creative experience. Creativity was apparent at a number of different levels throughout these workshops: from the choices made around materials, the techniques used for the weaving and in the way participants responded to using physical computing with a woven eTextile swatch. As a stand-alone activity without the interactive element, participants found much joy in their making, as it was a concrete and focused activity. But the steps of combining the non-conductive materials with the conductive, followed by connecting their work to the Arduino board and hearing the sounds was, for all who participated, the moment where many of their amazing ideas were realised.

There is something special about combining a traditional crafting activity like weaving to a computational one, using it in an environment which is untraditional, and transforming it into a creative technology toolkit. Bringing the two together has made this experience accessible for different people on different levels, whether it be giving them a better understanding of how technology might work or how hands-on making need not be fiddly or require sight. Using touch, the participants found their own way around the loom in a way personal to them.

Previous work with eTextiles has tended to emphasise the visual aspects that can be achieved with such creative toolkits - by creating interesting glowing effects with LEDs, that blink on and off, or that shine through thin layers of fabric creating intriguing effects. In this workshop we demonstrated that eTextiles can be very effective as a purely haptic medium, where the regularity of threads, the patterns that can be achieved, the bobbliness of some fibres versus the rougher feel of others, and even their smell all add to an intriguing surface with an interactive potential.

Technological toolkits such as Arduino and the vast array of conductive yarns and fabrics have endless opportunities for exploration. By not being bound to specific configurations but having the freedom to combine all types of material and applying any number of crafty making skill, there are endless opportunities for people to put their personal stamp on what they are making and to express something of who they are.

As an approach to imagining future technologies we found the creative workshop, similar to the findings by Rogers et al [17], to provide a safe environment in which people could come out with their own ideas. From hesitant beginnings they had grown in confidence and through their own making efforts, understood that their ideas and notions were valued. The design dimensions that they sketched, through their examples of interactive carpets to pull jokes, blankets to hide under and wall hangings to walk up to and touch, clearly indicate that there is room for more pleasurable technological experiences that go beyond having to compensate for the lack of sight. They indicate that eTextiles can form part of a new form of designing for accessibility that actually goes beyond accessibility, by putting the sensation of touch at the core of the experience - as something that is fun, inspiring and accessible to all.

CONCLUSION

eTextile pieces, simply put together by people using their own hands and imagination, can form a powerful way to tap into people's creativity and raise their curiosity. While many accessible technology approaches for blind and visually impaired users focus on resolving problems around reading and writing, our creative workshop approach demonstrated that a simple but open-ended physical computing toolkit can give people the opportunity to express themselves and develop something aesthetically pleasing to hold. Particularly at a time when the largely inaccessible touch screen has come to pervade all aspects of our lives, it is important to explore the potential of other, more tactile oriented surfaces and objects for people with different sensory characteristics. The interactive woven pieces produced during these workshops showed that eTextiles can create interfaces that are graspable, squeezable, stroke-able and that are surprising. They inspired participants to think wider, beyond the immediate problems of the here and now, towards technology designs that are about delight and enjoyment.

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